Journal of Biomedical Informatics 57 (2015) 263–277

Contents lists available at ScienceDirect

Journal of Biomedical Informatics

journal homepage: www.elsevier.com/locate/yjbin

Methodological Review

Examining the role of collaboration in studies of health information technologies in biomedical informatics: A systematic review of 25 years of research

Elizabeth V. Eikey [a,*], Madhu C. Reddy [b], Craig E. Kuziemsky [c]

[a] College of Information Sciences and Technology, The Pennsylvania State University, United States
[b] School of Communication, Northwestern University, United States
[c] Telfor School of Management, University of Ottawa, Canada

ARTICLE INFO

Article history:
Received 15 October 2014
Revised 31 July 2015
Accepted 5 August 2015
Available online 8 August 2015

Keywords:
Collaboration
Health information technology
Systematic review

ABSTRACT

Purpose: Our objective was to identify and examine studies of collaboration in relation to the use of health information technologies (HIT) in the biomedical informatics field.
Methods: We conducted a systematic literature review of articles through PubMed searches as well as reviewing a variety of individual journals and proceedings. Our search period was from 1990–2015. We identified 98 articles that met our inclusion criteria. We excluded articles that were not published in English, did not deal with technology, and did not focus primarily on individuals collaborating.
Results: We categorized the studies by technology type, user groups, study location, methodology, processes related to collaboration, and desired outcomes. We identified three major processes: workflow, communication, and information exchange and two outcomes: maintaining awareness and establishing common ground. Researchers most frequently studied collaboration within hospitals using qualitative methods.
Discussion: Based on our findings, we present the "collaboration space model", which is a model to help researchers study collaboration and technology in healthcare. We also discuss issues related to collaboration and future research directions.
Conclusion: While collaboration is being increasingly recognized in the biomedical informatics community as essential to healthcare delivery, collaboration is often implicitly discussed or intertwined with other similar concepts. In order to evaluate how HIT affects collaboration and how we can build HIT to effectively support collaboration, we need more studies that explicitly focus on collaborative issues.

1. Introduction

Collaboration is an essential part of the healthcare delivery system, but it is not often explicitly studied in research on health information technology (HIT). One challenge in studying collaboration is that it can be difficult to define. Based on the definition provided by Weir et al. [1] and for the purposes of this review, we define the collaboration as: *planned or spontaneous engagements that take place between individuals or teams of individuals, whether in-person or mediated by technology, where information is exchanged in some way (either explicitly, i.e. verbally or written, or implicitly, i.e. through shared understanding of gestures, emotions,* etc.*), and often occur across different roles (i.e. physician and nurse) to deliver patient care.*

Collaboration is a difficult concept to study because it often includes aspects of other concepts, such as coordination [2], cooperation [3], and communication [4]. Although all four terms focus on how individuals interact with each other to provide care, the extent of the interaction is different in each of these terms. According to Fuks et al. [4], "communication is related to the exchange of messages and information among people; coordination is related to the management of people, their activities and resources; and cooperation is the production taking place on a shared workspace" (p. 637). These three terms are interrelated. For example, the 3C Collaboration model describes *communication* as the exchange of information to generate commitments that are then managed by *coordination* so that individual care activities interact through shared spaces to work *cooperatively* to ensure the success of the overall care process [4]. While communication,

* Corresponding author at: 323 IST Building, The Pennsylvania State University, University Park, PA 16802, United States. Tel.: +1 412 401 7699.
E-mail address: eveikey@psu.edu (E.V. Eikey).

http://dx.doi.org/10.1016/j.jbi.2015.08.006
1532-0464/

coordination, and cooperation often work together to comprise collaboration, each individually fails to encompass the type of engagement and shared understanding highlighted in the above definition of collaboration. At its core, collaboration involves the development and testing of rules of engagement and shared understanding that facilitates *how* people work together in shared spaces [5].

The increased prevalence of chronic illness and the recognition of the benefits of team-based healthcare delivery are drivers for increased collaboration. Although the need for increased collaboration in healthcare has been well described [6,7], how to implement successful collaboration is not as well understood. Studies have examined many aspects of collaboration including education [8,9], teamwork [10,11], patient-centeredness [12], technologies' impact on collaboration [13], and designing for collaboration [14]. While there has been a great deal of focus on appropriately integrating HIT within clinical workflows, collaboration is often only implicitly discussed as an aspect of individuals' activities [15]. Consequently, unintended consequences can occur because HIT is not properly aligned with underlying collaborative processes [16]. Therefore, we need to better understand how HIT is situated in settings that are highly collaborative.

Given the goal of increasing collaborative care delivery [6], we believe that this is the ideal time to look at the state of research about collaboration and HIT. Therefore, in this systematic review, we aim to better understand how collaboration in HIT research has been studied within the biomedical informatics community over the past 25 years. We have three specific goals for this paper. First, we want to analyze existing research to describe the state of knowledge in the biomedical informatics community on collaboration in relation to HIT. Second, we want to develop a model to help researchers who are interested in studying collaboration and HIT. Finally, we want to identify future research directions for the biomedical informatics community in studying collaboration and HIT.

2. Methods

2.1. Research questions

Overall, our objective was to better understand the role of collaboration in HIT research within the biomedical informatics community. Consequently, we had the following research questions: (1) What types of HIT are part of studies on collaboration? (2) What are the methods used in studies of these technologies? (3) What particular issues do studies that explicitly discuss collaboration focus on? Answering these questions will enable us to highlight what researchers have noted about collaboration and HIT in ways that would be useful to other researchers and practitioners.

2.2. Literature search strategy

To identify relevant papers, the first author (EE) first conducted an extensive search of PubMed from 1990 to 2015. As instructed by a librarian, we used the MeSH terms "Medical Informatics" *or* "Medical Informatics Computing" *or* "Medical Informatics Applications" in an attempt to obtain the most relevant results. EE searched the titles and abstracts using the keywords "collaboration" *and* "technology." To narrow the number of results returned, EE used filters to ensure paper abstracts were in English and dealt with collaboration amongst individuals. The PubMed search yielded 258 total results, of which EE either downloaded or noted the citation for 76 papers.

In order to ensure no other potentially relevant papers were missed, EE also searched the Penn State University Libraries online. Using the keywords "collaboration" *and* "technology" to search abstracts and with an advanced search, EE used medical and health informatics journals' names (using the list of journals from [17]) as the publication title. EE also used filters to ensure papers were in English and peer-reviewed.

Finally, EE used Google Scholar to search conference proceedings, specifically MedInfo (IMIA: the International Medical Informatics Association) and AMIA (the American Medical Informatics Association). Because of the limitations of Google Scholar, EE searched for the keywords "collaboration" *and* "technology" anywhere in the document. The search within proceedings of AMIA yielded 371 results, and MedInfo yielded 70 results. EE pulled up each paper and searched for the terms "collaboration" and "technology" within each document and then determined if it met the initial inclusion criteria. EE downloaded and/or noted the citation of 53 of the 371 AMIA articles and 14 of the 70 MedInfo articles.

We intentionally did not search for concepts similar or related to collaboration, such as coordination or cooperation because we were interested in how the biomedical informatics community specifically has studied collaboration in relation to HIT.

2.3. Study selection & characteristics

We pre-identified 10 articles that dealt with both collaboration and technology in the biomedical informatics community before conducting the searches. However, all of these documents used the terms collaboration and technology somewhere in the text. The first author (EE) conducted the literature search. Fig. 1 shows the process of identifying and reviewing papers. During the first part of our search process, EE focused on papers in biomedical informatics-related journals and conference proceedings. Articles from these venues had to have both the terms "collaboration" and "technology" (in the abstract or title for the PubMed search, in the abstract for the Penn State University Libraries journal search, and anywhere for the Google Scholar conference search). They also had to be in English (the abstract for the PubMed and Penn State University Libraries searches and the whole document for the Google Scholar conference search) and had to be peer-reviewed.

Based on these criteria, PubMed, Penn State University Libraries, and Google Scholar returned 943 total results. For the second phase of our process, EE reviewed each abstract of these articles. Articles were excluded if they did not focus on team-level collaboration among people. As a result, EE downloaded the PDF and/or citation of 214 articles plus the 10 articles we had pre-identified for a total of 224.

For the next phase, EE read each article and compiled an Excel sheet with the authors, title, year, and publication of those 224 potentially relevant articles. After removing duplicates, manuscripts not completely in English, and partial manuscripts, EE then went through each of the remaining 173 articles extracting technology type, co-located vs. dispersed collaborations, modality (asynchronous, synchronous), location (e.g. hospital), country/continent, methodology, and collaborators. Of those, 75 were not relevant to our topic and thus removed. EE then conducted a thematic analysis similar to [18] and supported by [19]. Going through the articles, EE began noticing themes related to collaboration, which we eventually termed processes and outcomes (workflow, communication, information exchange and awareness, common ground). Once these themes were identified, EE went through each article again to extract data related to these processes and outcomes. The themes emerged from the analysis of the papers and were inductively identified. EE also considered the use of the term collaboration and other similar terms.

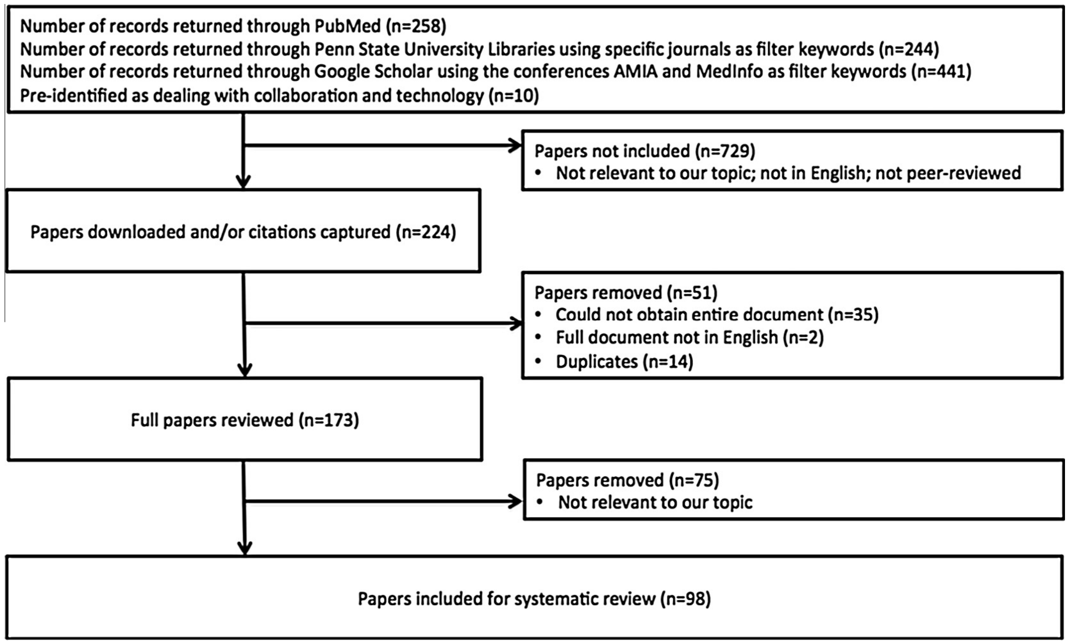

Fig. 1. Flowchart showing our process of identifying and reviewing papers.

The inclusion criteria were collaboration among people where technology was included for the purposes of patient care. Therefore, EE excluded articles where collaboration was among technological components, organizations (not people within those organizations), researchers, or information technology (IT) staff unless researchers and/or IT staff were collaborating for the purposes of patient care (not for the purposes of designing technology or giving recommendations only). EE excluded articles that focused on collaboration solely for medical education as this did not meet our requirement for a focus on patient care. While we did not evaluate manuscripts' quality according to a scoring scale, we did use a descriptive approach to evaluate them according to the guidelines in [20]. Based on these criteria, we ended up with a total of 98 articles. Using a descriptive approach, the other two authors (MR & CK) each evaluated those 98 papers and agreed they met our inclusion criteria. In the appendix, Table A.1 lists all the papers included in our analysis.

3. Results

3.1. Types of technologies studied

Telemedicine applications ($n = 25$) [21–42] and electronic medical records (EMR), electronic health records (EHR), and electronic patient records (EPR) ($n = 15$) [1,2,43–57] were among the most common systems studied (Table 1). As Table 2 shows below, there is an increasing number of articles ($n = 23$) that deal with telemedicine applications to support geographically dispersed medical teams, such as videoconferencing tools [22,26,28,30,31,35,37–42,55,58]. Many telemedicine applications were used for synchronous collaborations ($n = 15$) [23–26,28–30,32,35,36,39–42,49] (Table 3). Jarvis-Selinger et al. [28] found that videoconferencing "created a new context for team-based management, enabling members to communicate simultaneously when they otherwise would not have, thus fostering collaborative, multidisciplinary patient management" (p. 4, as cited in [27]). However, six telemedicine applications were used for both synchronous and asynchronous interactions [21,22,26,30,36,37] and two primarily for asynchronous interactions [33,57]. Kulik et al. [30] discussed using a telemedicine application for the purposes of treating patients with AIDS after hospital discharge. They used asynchronous

Table 1
Studies on technology types.

Technology type	# of Studies
Telemedicine applications	25
EMR, EHR, EPR	15
CPOE	5
Mobile technology (PDAs, pagers, mobile phones, etc.)	5
Web 2.0 applications, internet, online health communities	5
Picture archive and communication system (PACS)	3
Medicine dispensing devices and pharmacy barcode systems	3
RFID and smartcard systems	2
HIT generally	17
Other/specific applications	18
Total	98

Table 2
Studies on co-located and dispersed medical teams.

Medical team location	# of Studies	Most common type of technology	# of Studies
Co-located	43	EMR, EHR, EPR	13
Dispersed	41	Telemedicine applications	23
Co-located/dispersed	5	PACS; telemedicine applications	2; 2
NA	9	HIT generally	9
Total	98		

Table 3
Studies on different modalities (asynchronous, synchronous, mixed).

Modality	# of Studies	Most common type of technology	# of Studies
Asynchronous	25	EMR, EHR, EPR	7
Synchronous	20	Telemedicine applications	15
Asynchronous/synchronous	24	EMR, EHR, EPR	8
NA	29	HIT generally	12
Total	98		

communication through the exchange of medical dossiers, images, and email as well as synchronous communication through teleconferencing. Also in the context of after hospital care, Paganelli et al. [33] used asynchronous communication (SMS and email) in combination with a context-aware system to alert relatives, providers (general practitioner or nurse), and emergency operators (if necessary) if a patient needed assistance at home. This system was intended to help providers collaborate with one another and with patients' relatives in order to deliver patient care. For lower alert levels, no response from the relative or provider was required. However, at higher alert levels, a response was required from either provider or relative (or both).

As Table 2 also highlights, EMR, EHR, and EPR systems were often studied in the context of co-located collaborations ($n = 13$) [1,2,44–46,48,50–54,56,59]. For instance, Feufel et al. [46] studied how the EMR interacts with people and processes while observing physicians collaborating in the emergency department (ED). They found work practices often compensate for technical limitations and then provided design recommendations, such as support for effective multi-user collaboration during control tasks. One article dealt with EHR systems for both co-located and dispersed medical teams [57]. It was a national questionnaire to understand provider usability issues.

As illustrated in Table 1, some studies ($n = 17$) examined HIT more generally [60–76], yet others ($n = 18$) discussed specific applications or components [12,77–93]. For instance, Bång et al. [78] conducted a study regarding the advantages and disadvantages of NOSTOS, an experimental, computer-augmented work environment, which provides a physical interface for computer-based patient records to support collaboration. Mejia et al. [80] developed SOLAR, an application that supports collaboration through awareness and informal communication in hospital work. Other systems discussed included CPOE ($n = 5$) [13,94–96], mobile technology (such as PDAs, pagers, mobile phones, etc.) ($n = 5$) [97–101], web 2.0 applications, internet, online health communities ($n = 5$) [102–106], picture archive and communication system (PACS) ($n = 3$) [107–109], medicine dispensing devices and pharmacy barcode systems ($n = 3$) [110–112], and RFID and smartcard systems ($n = 2$) [113,114].

3.2. Study settings and methodologies

The study methodologies were examined from three aspects: (1) the user groups using the technologies, (2) the study setting, and (3) data collection methods. As Table 4 highlights, much of the research on collaboration and HIT focused on clinician-to-clinician interactions ($n = 71$) [1,2,13,23–32,35–44,46–49,51–58,60–66,68,70,73–82,84,86,88,92–96,98,99,101,103,107–109,114,115]. Some studies focused on collaboration between nurses and physicians. For example, Wu et al. [92] studied the effects of text-based communication on nurse-physician collaboration. They found that it leads to depersonalization and thus decreases collaboration. Bång et al. [78] designed technology to support collaboration among physicians and nurses in the ED.

Some studies looked at how physicians collaborate with one another through technology. For instance, Maglogiannis et al. [49] described a web-based system allowing physicians to collaborate with one another and share EHRs through real-time audio, video, and messaging. Others focused on nurse–nurse collaboration. For example, Tang et al. [116] looked at how nurses in a remote intensive care unit (ICU) consult one another through technology to deliver patient care.

While clinicians were the most common user group, there is also growing interest in the role that patients play in the healthcare delivery process and HIT use ($n = 12$) [22,23,29,40,48,57,68,73,87,91,102,111]. For instance, Bowles et al. [22] studied how nurses and at-home patients with heart failure use video phones to work toward their care (to teach self care and treat symptoms). Researchers have not only considered the role that patients play in their healthcare, but also the role that family members play ($n = 6$) [12,34,89,90,104,112]. For example, Porter [12] discussed a system for parents of children with asthma to participate more in the decision-making process and care of their child. Safran [89] described Baby CareLink, a system for parents and clinicians to collaborate on the care of their premature babies. While clinician–clinician and clinician–patient (or family of the patient) comprised the majority of studies, researchers have also focused on other interactions, such as clinician–administrative staff ($n = 4$) [1,67,94,115], clinician–EMS staff ($n = 1$) [117], clinician–transport supervisor ($n = 1$) [83], homecare worker–general provider ($n = 1$) [50], homecare worker–homecare worker ($n = 1$) [71,97], and pharmacist–pharmacy staff ($n = 2$) [69,110].

These different types of user groups can be found in various settings and have been studied using a variety of methods. We differentiate these settings primarily by geographical location and inpatient vs. outpatient setting. Most authors reported the location of their study as the United States ($n = 48$) [1,2,12,13,21,22,25,27,35–39,41,43,45–47,53–56,60,63,65,66,68,70,73,79,82,83,86,88–90,94,95,98,100,101,105,107,110–112,114,115], followed by Canada ($n = 7$) [28,29,64,71,72,87,92], Sweden ($n = 5$) [24,77,78,85,93], Finland ($n = 4$) [48,57,58,69], United Kingdom ($n = 4$) [51,62,67,91], Norway ($n = 3$) [33,50,102], Denmark ($n = 2$) [96,97], France ($n = 2$) [31,44], Japan ($n = 2$) [26,52], Taiwan ($n = 2$) [32,99], Croatia ($n = 1$) [30], Greece ($n = 1$) [84], Ireland ($n = 1$) [109], Italy ($n = 1$) [34], Republic of Albania ($n = 1$) [42],

South Korea ($n = 1$) [40], Spain ($n = 1$) [103], The Netherlands ($n = 1$) [81], and Wales ($n = 1$) [61].

One study reported the location just as Europe [108], and another had two locations, the United States and Canada [76].

Table 4
Types of users collaborating.

User group[a]	# of Studies
Clinician–clinician	71
Clinician–patient	12
Clinician–family of patient	6
Clinician–administrative staff	4
Clinician–EMS staff	1
Clinician–transport supervisor	1
Homecare worker–general provider	1
Homecare worker–homecare worker	2
Pharmacist–pharmacy staff	2
Other	12
NA	2

[a] Articles could study more than one type of user group interaction.

Table 5
Study settings.

Setting	# of Studies
Hospital	60
Home	10
Nursing home	2
Pharmacy	1
Pre-hospital–hospital	1
Hospital–home	3
Hospital–therapy center	1
Ambulatory clinic	1
General practice	1
Oral medicine center	1
Various	5
NA	12
Total	98

As Table 5 illustrates, many of these studies focused on collaboration and technology in inpatient settings, primarily hospitals ($n = 60$) [1,2,12,13,26–28,30–32,36–44,46,48,49,51,52,54–56,58,61–63,65,66,68,70,73,76,78–82,86,88,91–93,95,96,98,100,101,103,108–110,113,114]. Within hospitals, a number of the studies were conducted in the ICU ($n = 6$) [39,51,53,55,82,98] and the ED ($n = 5$) [12,43,63,78,93]. These settings are busy, information-intensive settings where collaboration is essential for providing effective patient care. However, there is an increasing number of studies focused on outpatient settings, such as homes ($n = 10$) [22,29,34,50,71,84,85,87,111,112], nursing homes ($n = 2$) [60,97], and ambulatory clinics ($n = 1$) [107]. There is additional research ($n = 3$) attempting to bridge the divide from the home to the hospital through telemedicine applications [89,90,102]. In order to obtain the types of data needed to understand collaboration in the various settings, researchers have primarily utilized qualitative methods ($n = 36$) [1,13,24,29,43,44,46,48,50–53,55,58,61,62,64,66–68,71,72,77,79,80,91–96,98,100,109,110,115], as shown in Table 6. Interviews ($n = 23$) and observations ($n = 18$) (or a combination of the two) were conducted most frequently. For example, Ash et al. [115] conducted observations, interviews, and focus groups to understand perceptions of the CPOE and its impact on collaboration and other organizational processes within hospitals. Some studies ($n = 9$) have used only quantitative methods [22,38,39,57,69,88,90,103,111]. Others ($n = 6$) have used mixed methods (qualitative and quantitative methods) [60,63,85,97,112]. Of the remaining papers, twenty-nine were overviews of technology systems or applications [12,25–27,30–32,34–37,40–42,49,70,78,82–84,86,87,89,99,101,107,108,113], ten were literature reviews [2,21,23,28,33,65,74,75,81,106], and nine were a variety of study types or other methods not previously listed [45,47,54,56,73,76,102,104,105,114], such as computational methods [54].

3.3. Processes

Through the review of literature, we found that while many studies identified collaboration as an issue of interest, they did not necessarily focus directly on collaboration. Instead, they examined healthcare processes often central to collaboration. We identified three major processes from these studies: (1) workflow, (2) communication, and (3) information exchange. Most studies mentioned at least one of these processes, as shown in Table 7.

3.3.1. Workflow

Collaboration is often a crucial part of workflow, but the meaning of workflow can vary [118]. For the purposes of this review, we view workflow similar to Niazkhani et al. [119], who define clinical workflow as "the flow of care-related tasks as seen in the management of a patient trajectory: the allocation of multiple tasks of a provider or of co-working providers in the process of care and the way they collaborate" (p. 540). As Table 7 shows, a number of studies ($n = 44$) mention workflow as part of their research on collaboration (see Table A.1). One issue with designing HIT is that modeled workflow is often rigid and does not account for exceptions which are becoming a normal part of medical work [2,115]. Technology has to be customizable and flexible to fit workflow in healthcare settings [94,110].

Table 6
Types of study/methods used.

Methods/study type	# of Studies
Qualitative	36
Quantitative	9
Qualitative and quantitative	6
Literature review	10
Overview of technology	28
Other	9
Total	98

Table 7
Types of processes mentioned in studies.

Processes mentioned[a]	# of Studies
Workflow	44
Communication	77
Information exchange	33
None	12

[a] Articles could study more than one type of process.

Researchers have been interested in how technologies support collaboration within clinical workflows [70,78,82,93,107]. For instance, Bång et al. [93] designed NOSTOS to fit current clinician workflow since the technology was modeled after existing tools. Macyszyn et al. [107] designed and implemented a departmental PACS and found that it improved workflow efficiency and collaboration. Starmer and Guise [82] designed and implemented a ventilator management dashboard for patients in the ICU. The system was meant to support clinical workflow (such as shift changes, physician rounding patterns, and unit staffing patterns) to achieve a high level of compliance. Despite this, the system did not adequately support batch charting and was not integrated with charting tools and the CPOE, which resulted in workflow inefficiencies.

At the same time, a number of studies have looked at how technologies impact clinician workflow [21,28,43,55,60,62,65,94,98]. Researchers have found that technology often have a negative impact on clinical workflow by disrupting work [21,55,60] or altering normal work practices [43,65,94,98], which can result in increased cognitive load [55,65,98], poor patient care [43,65], and errors [55]. For example, Patel et al. [65] conducted a review of studies and drew examples from their own research to examine aspects of clinical workflow. They described how both collaborative (e.g. interruptions to discuss patient care) and coordinative factors (e.g. handoffs) can contribute to workflow delays. Looking at the ED, psych ED, and ICU, they found that loss of information at shift change, multitasking, and frequent interruptions result in bottlenecks in the workflow.

Abraham et al. [43] studied the EMR and its impact on clinical workflow in the ED. While EMR use led to better documentation and management of patient care, it caused clinicians to alter their work activities, which resulted in additional steps in the patient care process. These altered work activities occurred when clinicians had to exchange information with others through the EMR, move locations to use the EMR, and add patient information into the EMR. These modifications to normal work activities result in bottlenecks in the workflow, which can have a negative impact on patient care. Reddy et al. [98] studied the impact of pagers on clinical workflow in the surgical intensive care unit (SICU) and found it alters clinicians' work practices. They found mixed results on the impact of this tool on collaboration. Pagers removed or lowered the hierarchical boundaries, which in some ways facilitated collaboration. However, in other ways, it caused loss of control with simultaneous notification. Pagers caused information overload and de-contextualization, and they lack feedback mechanisms, which impacted clinicians' ability to make decisions and interact with one another. In spite of the workflow issues, only nine studies mentioned workarounds [46,64,65,68,94,109–111,115]. Improving workflow efficiency can have positive effects on communication and collaboration among clinicians [65].

3.3.2. Communication

Communication, defined as the exchange of information to generate effect, test assumption, and establish and maintain relationships [16], is a key aspect of collaboration. As Table 7 illustrates, we found many studies ($n = 77$) mentioned communication (see Table A.1). HIT opens new channels for both synchronous and asynchronous communication, but the findings about the effects of HIT are mixed. Although Ash et al. [115] did not explicitly emphasize collaboration, they discussed the need to understand the impact of HIT on communication among key healthcare staff. Since clinicians cannot always directly communicate with one another, they often use HIT to interact (i.e. communicate) with each other. However, this limited direct communication can cause misunderstandings about the information being exchanged and contribute to medical errors [2]. Technology can facilitate communication and support collaborative work, but the technology needs to be standardized across different settings in order to prevent human error and reduce patient safety risks [56]. Additionally, each system seems to have its tradeoffs.

There are mixed findings on HIT's impact on communication [60]. In the case of the EMRs, EHRs, and EPRs, clinicians reported a negative impact on team interactions and less effective communication [46]. Yet Vawdrey et al. [56] found EHRs improved communication and collaboration among clinicians. Similarly, Ash et al. [115] found that nurses and physicians reported improved communication with CPOE systems because there were less negative interactions about legibility and timely entry of orders. Even mobile technology had mixed effects. Reddy et al. [98] found that pagers can both facilitate collaboration and flatten communication in hospitals. Additionally, pagers themselves only allow one-way interaction, which can hinder communication between clinicians. Another issue is the ability for tools to capture informal communication within hospitals [80]. Face-to-face interactions happen naturally in hospitals as clinicians move around to do their work. This makes many technologies inappropriate for these types of interactions [80].

Both asynchronous communication (such as through the EHR or CPOE) and synchronous communication (face-to-face) cause interruptions, but synchronous communication allows for questions to be answered quickly [65]. Weir et al. [1] reported that clinicians prefer verbal communication and often avoid reading nurses' notes because it requires too much time and effort. The lack of direct interaction resulted in fewer opportunities for team negotiations [96]. For instance, since physicians created the orders in the systems, nurses were often excluded from information regarding the ordering process. Breakdowns in communication and physician–nurse workflow caused delayed order processing [13], which creates concern for patient safety and quality of care. Alexander et al. [60] reported that medical staff in nursing homes felt that face-to-face communication led to better quality communication. However, they also reported that those nursing homes with better integrated HIT were able to communicate about patient decline faster and more often with the need for less face-to-face interactions.

Some technology has improved the efficiency of communication especially for dispersed medical teams. For example, Melby and Hellesø [50] found that e-messaging between homecare providers and general practitioners allowed for more efficient communication. However, this increase in efficiency was not without its drawbacks as they also found e-messaging decreased personal communication. While some believed less face-to-face meetings were better, some reported the limited interpersonal communication negatively affected their ability to build relationships with colleagues, which ultimately impacts the effectiveness of their collaborations. While some technologies limit face-to-face interactions, some promote more personal communication, such as telemedicine systems with video capabilities. One example is ARTEMIS, which allows physicians to communicate through a desktop teleconferencing system [27].

For patient–provider (or family of patient and provider) interactions, technology can improve communication. When user groups are distributed, technology allows interaction and communication where there otherwise would not be. For example, Safran [89] found that with Baby CareLink, parents of premature babies reported better communication with clinicians and more satisfaction with the care provided. Even though parents are remote from the neonatal intensive care unit (NICU), they were able to communicate with clinicians and actively make decisions about their baby's care.

3.3.3. Information exchange

Information exchange is similar to communication. However, information exchange is only focused on providing and sharing information while communication provides both information and a means to act in response to that information [16,64]. While Table 7 shows a number of studies ($n = 33$) that mention information exchange (see Table A.1), very few really discuss it in detail. Within HIT, such as EHRs, exchanging information should improve communication, which also improves quality of care [48].

Information is a crucial piece of collaborating to deliver patient care. Mejía et al. [80] found that information exchange comprised nearly 27% of informal interaction between physicians and medical interns, and they often exchanged information stored in medical records. But there are mixed findings on how well HIT supports information exchange. Melby and Hellesø [50] found e-messaging improved information exchange between homecare workers and general practitioners. Physicians were satisfied with how well HIT support information exchange between co-located medical staff but were less pleased with HIT's ability to support cross-organizational and dispersed teams [57]. Weir et al. [1] found clinicians were unhappy with templates for computerized documentation as they did not adequately support information exchange.

3.4. Outcomes

We identified two major issues, (1) maintaining awareness and (2) establishing common ground, both of which could be considered desired "outcomes" of effective design of HIT to support collaboration. Interestingly, while most studies mention as least one process, the majority of studies did not discuss these outcomes (Table 8) highlighting the focus on process instead of potential outcomes.

3.4.1. Maintaining awareness

In order to collaborate effectively, healthcare providers must have an understanding of what is happening around them. This concept of not only sharing information but also sharing information about others' activities is known as awareness [53]. As Table 8 shows, we found twenty-four articles that used the term awareness (see Table A.1). For instance, Reddy et al. [53] and Kuziemsky and Varpio [64] conducted interviews and observations to better understand awareness in clinical environments and make HIT recommendations. Reddy et al. [53] used this data to evaluate a system's collaborative features; whereas Kuziemsky and Varpio

Table 8
Types of outcomes mentioned in studies.

Outcomes mentioned[a]	# of Studies
Awareness	24
Common ground	5
Neither	70

[a] Articles could study more than one type of outcome.

[64] used their data to differentiate types of awareness, such as patient, team member, decision-making, and environment. Other researchers developed applications to support awareness [41,80]. Welch et al. [41] found 2D videoconferencing between physicians and paramedics is not sufficient enough to provide awareness in such a stressful and changing setting. In order to establish awareness, they developed a 3D medical collaboration technology, which allowed physicians and paramedics to collaborate more efficiently and effectively from distributed work environments [41]. Mejia et al. [80] designed SOLAR, a collaborative system that supports co-located hospital interactions by providing awareness of workers' locations and information on shared tasks. HIT can support clinicians by providing awareness of others' activities and locations [53].

Awareness is nearly invisible in face-to-face interactions. However, in asynchronous, document-mediated settings, awareness is not as natural, and breakdowns become apparent. Information technology has been used to help provide awareness in these contexts [1]. Reddy et al. [53] explained that the EMR has the ability to provide this awareness if it includes information about both the individual's activities and others' activities. Facilitating awareness among clinicians can reduce errors and harmful interventions [41]. While maintaining awareness may be difficult in chaotic hospital environments, it is necessary for effective collaboration. When HIT fails to facilitate awareness, opportunities for clinician collaboration are missed [80].

3.4.2. Establishing common ground

Collaboration is not just dependent on the exchange of data but also requires tools for establishing and maintaining common ground, the knowledge and shared understanding needed by two or more communicating parties to enable communication to occur [1,120]. These tools can help integrate different healthcare team members as part of collaborative care delivery. Common ground is a key part for forming a shared situation model amongst team members [1]. By sharing information and communicating effectively, healthcare providers create common ground or shared knowledge or understanding amongst themselves, which is essential to deliver quality patient care. The majority of studies did not discuss common ground. As Table 8 shows, five studies mentioned common ground (see Table A.1), but most did not go into great detail about it. Researchers have found HIT may interfere with the ways healthcare providers establish and maintain common ground [1], which in turn impact collaboration. Weir et al. [1] found improvements to documentation input efficiency can actually decrease users' ability make sense of the information and create common ground amongst each other.

4. Discussion

We now turn our attention to a discussion of the broader questions of understanding collaboration, system design for collaboration, and future research directions.

4.1. Understanding collaboration

While there has been significant research on collaboration and HIT, our review identified issues around how to define studies as being focused on collaboration. Table A.1 shows all the papers from our review, whether the paper also used the term cooperation and/or or coordination, and which of the processes and/or outcomes from our analysis it contained. While fields such as Computer-Supported Cooperative Work (CSCW) and Artificial Intelligence have been trying for a number of years to develop distinct definitions to differentiate cooperation, coordination, and collaboration, these communities have still not been able to agree to canonical definitions, and those terms are still are often used interchangeably [121,122]. Our findings show that while conceptual distinctions do exist, it is far more challenging to differentiate these terms in practice. Even when studies are classified as collaboration according to our search criteria, they may still incorporate the other concepts. For instance, Bowles et al.'s work [22] dealt with a telemedicine application where a patient's vitals are sent to a nurse to coordinate care, and the patient and nurse also collaborated via video. Thus, the study had elements of both collaboration and coordination.

However, this blurring of terms can make it difficult to effectively evaluate HIT support for collaboration. One way to differentiate these terms is to view them on a spectrum. So, for instance, on one end is coordination, and as one moves from coordination to collaboration, there are increasing responsibilities, such as the need for the development of collaborative competencies (e.g. common ground) [123,124]. Therefore, the requirements for designing HIT that supports collaboration will be different than the requirements for HIT that focuses on supporting coordination or cooperation [3,125].

As Table A.1 highlights, although these studies talk about collaboration, very few studies ($n = 5$) actually define it [1,13,39,50,85] (Table 9). This can make it difficult to determine if what is being studied meets our definition of collaboration (especially if work practices are not described and collaboration is discussed implicitly). Interestingly, only two studies discussed all the processes and outcomes [64,76]. Further, few studies explicitly discuss outcomes of collaboration as twenty-four studies discuss awareness [1,2,37,41,43,44,51,53,57,58,62,64,65,67,75–78,80,81,93,108,109,114], and only five studies discuss common ground [1,46,64,76,79]. The lack of discussion about explicit properties of collaboration may indicate that such studies are not about collaboration but rather about coordination or cooperation or that collaboration was implicitly studied as an aspect of other work practices or HIT design.

Table 9
Definitions of collaboration in papers.

Reference	Definition provided
Aarts et al. [13]	"Both the concepts of professional collaboration and workflow have the notion of the involvement of multiple individuals, but the first [collaboration] emphasizes the synchronous and interactive aspect of getting work done." p.3
Karlsudd [85]	"The term 'collaboration' is defined in this context as an exchange of resources and experiences among members in a system." p. 688
Melby and Hellesø [50]	"Interprofessional collaboration refers to any situation in which people work across organisational boundaries towards a positive end. In other words, we employ a wide understanding of the concept of collaboration. The type of collaboration we study is loose, generally informal and not strictly organised, although it may continue over a long period." p. 345
Ruesch et al. [39]	"'True collaboration is a process, not an event. It must be ongoing and build over time, eventually resulting in a work culture where joint communication and decision making between nurses and other disciplines and among nurses themselves becomes the norm.'" (as cited in [39]) p. 594
Weir et al. [1]	"Nearly all definitions of collaboration include the concept of shared sensibility, a collective perspective that includes information, norms, social expectations, activity goals and meaning. A sense of collaboration can range from the loosely structured experience of order we feel when we travel through crowded airports, to the tightly knit collaborative organization of a rowing crew." p. e63

4.2. Collaboration space model

The desired results of collaborative care delivery, such as patient safety or patient-centered care, are well described [6]. However, in light of the challenges in defining and studying collaboration, we believe that there is a need for a model to enable researchers and practitioners to more explicitly consider collaboration as a prerequisite to achieving these outcomes. As our findings have indicated, there is much variation in how collaboration is represented and described in HIT studies. Consequently, we have begun to develop a model to help situate research on collaboration and to highlight potential areas for further work [126]. Models of the communication space have enabled the design and evaluation of HIT to support interdisciplinary communication [127]. Previous systematic reviews on HIT have used frameworks such as Donabedian's Structure-process-outcome model [128], IOM dimensions of quality healthcare delivery [129], and an IT benefits framework [130], to structure the results. Furthermore, systematic reviews of information technology innovations in healthcare have emphasized the need to consider the relationship between context, structure, and processes when designing interventions [131]. While our review identified a number of studies on collaboration and HIT, we did not identify an overarching model that captures the "collaboration space" in this domain. Consequently, we have expanded on the aforementioned models and concepts to develop a model of the collaboration space (Fig. 2) consisting of four main concepts based on our results.

- *Technology* refers to the focus of design of a HIT, such as patient or provider, as well as the functionality of the HIT, such as documentation.
- *Context* refers to the user groups who work together, setting (e.g. inpatient, community, mixed), and the modality (i.e. synchronous, asynchronous, or mixed) where a system is used.
- *Processes* highlight the essential collaborative processes of workflow, communication, and information exchange to be supported.
- *Outcomes* represent the goals of what successful HIT should do in collaborative settings. We suggest that the development and maintenance of awareness and common ground are fundamental collaborative outcomes that are needed in order to achieve patient care outcomes.

Overall, the collaboration space model outlines the concepts and the linkages between them with respect to collaboration and HIT. Furthermore, this model provides researchers with a common set of terms when examining collaboration and HIT to enable people to think more explicitly about collaboration. We do not view the concepts in the collaboration space model as exhaustive but rather as the most common components of collaboration.

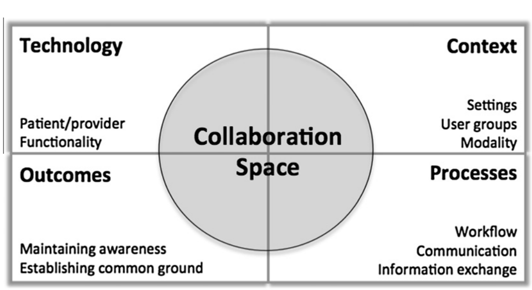

Fig. 2. Collaboration space model.

4.3. System design for collaboration

The collaboration space model draws attention to the fact that designing HIT to support collaboration is a complex and nuanced activity that requires understanding many different aspects of a setting. For instance, one important aspect for successful design of collaborative HIT is the need to understand what the collaborative outcomes (awareness and common ground) should be [123,124]. Part of establishing common ground is ensuring all team members are on the "same page" with respect to the rules of engagement for working collaboratively. Without such rules, technology that is designed to support collaboration, no matter how well it may be designed, may actually widen the gap between individual and group tasks. How different user groups or roles interact with HIT as part of collaborative care delivery must also be understood because HIT can pre-define roles in ways that shift responsibilities [96], resulting in confusion regarding who is responsible for what tasks and workarounds to solve the issues. Role-based access is one mechanism that highlights this issue [96]. In order to direct workflow, sometimes the rules dictated by the system and policies are ignored. For example, Wentzer et al. [96] found that some physicians would log in the system and allow nurses to continue medication work under their user rights.

The collaboration space model also draws attention to the fact that HIT needs to be designed to support specific processes of collaborative care delivery and integrate the collaborative workflows of different healthcare professionals. When this integration does not happen, workarounds often result from the gaps between the functionality of HIT and what is needed to effectively support collaboration. For instance, ARTEMIS [38], a system to support real-time consultations was implemented, but it did not support the physicians' needs to schedule consultations without due notice. As a result of this workflow issue, its collaborative consultation functions were not used.

The model also highlights that a first step in designing new technologies is to understand how collaboration is situated in the particular context, the processes (i.e. workflow, communication, and information exchange) within the context, and the role that existing tools or physical artifacts (i.e. paper-based tools) play in facilitating collaboration [53]. Otherwise, we find that existing collaborative practices may break down due to poorly designed tools and result in potentially avoidable workarounds. Despite the capabilities of HIT, paper artifacts, such as paper-based notes and orders written on appointment forms, allow clinicians to by-pass the system in order to collaborate more effectively and direct workflow [16,132–135].

A challenge with many existing systems is they lack flexibility for supporting the collaborative needs of healthcare providers [16,41,96]. For instance, Wentzer et al. [96] found that a CPOE system was not flexible enough to support the physician–nurse collaboration required for the medication order process. Research calls for more customizable and flexible systems in order to adequately support collaborative work practices in healthcare settings [94,110]. Unfortunately, HIT does not always match the fast-paced, collaborative demands of healthcare work.

4.4. Future research directions

Based on our findings we have identified several future research directions. First, one major challenge is to start understanding the distinctions and overlaps of collaboration and the relationship between coordination, cooperation and collaboration. In particular is the need to move from conceptual distinctions to studying these terms in practice. A better understanding of the relationship and differences between coordination, cooperation and collaboration

Table A.1
Illustration of which articles discuss collaboration and other terms, processes, and outcomes.

Article by Author	Year	Collaboration	Other Terms		Processes			Outcomes	
			Coordination	Cooperation	Workflow	Communication	Information Exchange	Awareness	Common Ground
Aarts et al.	2006	■	■		■	■			
Abraham et al.	2009	■	■		■	■	■	■	
Ackerman & Locatis	2011	■			■	■			
Alexander et al.	2014	■	■		■	■			
Alsalamah et al.	2013	■	■						
Ash et al.	2001	■			■	■			
Ash et al.	2003	■			■	■			
Atwal et al.	2014	■				■			
Bång & Timpka	2007	■	■		■	■		■	
Bång et al.	2004	■			■	■		■	
Bång et al.	2003	■	■		■			■	
Berhe et al.	2010	■	■		■	■			
Bowles et al.	2010	■							
Bringay et al.	2006	■	■			■	■	■	
Broome & Adams	2005	■	■		■	■		■	
Bruun-Rasmussen et al.	2003	■	■		■	■	■	■	
Buono et al.	2006	■	■			■			
Cady & Finkelstein	2012	■	■	■	■				
Chang et al.	2013	■							
Dorr, Jones, Wilcox	2007	■				■			
Ekeland et al.	2010	■	■			■			
Falkman et al.	2008	■		■	■	■	■		
Farup et al.	2002	■					■		
Feufel et al.	2011	■	■			■			■
Gagnon et al.	2008	■					■		
Ganiatsas et al.	2002	■		■		■	■		
Gong et al.	1997	■							
Hori et al.	2005	■				■	■		
Hsieh et al.	2013	■							
Jagannathan et al.	1995	■	■	■		■			
Jarvis-Selinger et al.	2008	■			■	■			
Jarvis-Selinger et al.	2011	■				■	■		

(continued on next page)

Table A1 (*continued*)

Article by Author	Year	Collaboration	Coordination	Cooperation	Workflow	Communication	Information Exchange	Awareness	Common Ground
Kane & Luz	2013								
Karasti et al.	1998								
Karlsudd	2008								
Kaspar et al.	2013								
Kim et al.	2007								
Klapan et al.	2002								
Kreps & Neuhauser	2010								
Kulik et al.	1997								
Kuziemsky & Varpio	2011								
Laitinen et al.	2014								
Lee et al.	2003								
Macyszyn et al.	2013								
Maglogiannis et al.	2006								
Martínez-García et al.	2013								
McKnight et al.	2001								
Mejia, Favela, Moran	2010								
Melby & Hellesø	2014								
Morrison et al.	2011								
Nanji et al.	2009								
Nielsen & Mengiste	2014								
Niimi & Ota	2013								
Obstfelder et al.	2007								
Ong et al.	2013								
Paganelli et al.	2008								
Parlak et al.	2012								
Patel et al.	2008								
Paul et al.	2008								
Pinelle & Gutwin	2005								
Plasters et al.	2003								
Porter	2001								
Pratt et al.	2004								
Qureshi et al.	2010								
Raman et al.	1997								
Reddy et al.	2008								
Reddy et al.	1993								

(*continued on next page*)

Table A1 (*continued*)

Article by Author	Year	Collaboration	Coordination	Cooperation	Workflow	Communication	Information Exchange	Awareness	Common Ground
Reddy et al.	2003	●			●	●			
Reddy et al.	1997	●			●	●			
Reeder et al.	2013	●	●			●			
Ruesch et al.	2012	■	●		●	●			
Safran	2003	●				●			
Safran et al.	2005	●	●			●			
Schraagen & Verhoeven	2013	●	●	●				●	
Shih et al.	2010	●				●			
Simpson	2008	●				●			
Starmer & Giuse	2008	●	●		●	●			
Stein et al.	2009	●	●		●	●	●		
Stellefson	2013	●	●			●	●		
Sung et al.	2000	●							
Swinglehurst et al.	2011	●	●		●	●		●	
Tang et al.	2006	●			●				
Tiwari et al.	2011	●			●	●			
Unertl et al.	2007	●			●	●			
van der Eijk	2013	●	●			●	●		
Vawdrey et al	2011	●	●		●	●			
Viitanen et al.	2011	●	●	●	●	●	●	●	
Vimarlund et al.	1999	●				●	●		
Weir et al.	2011	■	●			●	●	●	●
Welch et al.	2009	●						●	
Wentzer et al.	2007	●	●	●	●	●			
Westerling et al.	2010	●			●	●			
Wright et al.	2009	●	●		●	●			
Wu et al.	2012	●	●		●	●	●	●	●
Wu et al.	2014	●	●		●	●			
Wu et al. (Davis, Bell)	2012	●			●	●		●	
Zangara et al.	2014	●				●	●		
Zhu et al.	2011	●			●	●	●		

Key		
	●	Explicitly mentioned term
	■	Provided definition of collaboration

would enable us to better design and evaluate systems for the task at hand.

Second, much of the existing studies have looked at how telemedicine systems have supported collaboration among geographically dispersed medical teams. In some cases, technical limitations had made these options less viable. However, current advancements in video-conferencing and mobile technologies have made non-co-located collaboration a real option. A great deal of research has also focused on systems (e.g. EMR/EHR/EPR, CPOE) to support co-located collaborations. We must continue to study technology for both co-located and dispersed medical teams.

Third, in order to fully understand collaboration in healthcare, we must expand the research contexts where studies are conducted. As more care is being delivered outside of hospitals, we need to focus on collaboration in other settings, such as outpatient centers and within the home. Expanding research settings may also extend the user groups involved in collaboration and HIT. While some studies looked at collaboration between physicians and patients [22,23,29,40,48,57,68,73,87,91,102,111], most research has focused primarily on clinicians. Especially with the patient-centered healthcare approach, we believe all types of user groups need to be explored, including patients, patients' families, clinicians, IT staff, and non-clinical staff because they all have a hand in collaborative healthcare delivery.

Finally, we need to evaluate how well the HIT features explicitly support or do not support collaboration [53]. Although studies have, for instance, examined the effects of HIT on workflows, there has often been little discussion of how well collaboration is supported. Rather the discussion is whether the system is integrated into the workflow and how easily it can be used. For example, one interesting research question is how can we study the collaborative features of HIT [53]? The collaboration space model provides an explicit model to address that question by outlining the necessary features for the design and evaluation of HIT to support collaboration.

4.5. Limitations

The studies that have been included in this review are not an exhaustive list of collaboration studies. As in any systematic review, we may have not identified some studies because of a misunderstanding about the title, abstract, or text. Second, we may have missed some studies because of the search criteria that we used. There may have been papers that discussed collaboration and HIT that were not found using our search terms. We acknowledge that excluding search terms such as coordination or cooperation means our search is not an exhaustive list of studies that may also include aspects of collaboration in addition to these other terms. While these limitations may have affected our ability to identify more papers that focused on collaboration and HIT, we believe the papers we have identified are a good representation of what has been studied in this community on collaboration related to HIT over the last 25 years. Our goal with this systematic review was not to detail an exhaustive list of articles or to distinguish collaboration, cooperation, and coordination from one another. Our purpose was to understand the state of science on how researchers in the biomedical informatics community have understood and studied collaboration. Often this means that collaboration is intertwined with other similar concepts like coordination and cooperation, which makes sense given that effective patient care often deals with all three concepts.

5. Conclusions

While collaboration is being increasingly recognized in the biomedical informatics community as essential to healthcare delivery, it is still often implicitly discussed in the research and intertwined with other similar concepts. The challenges of supporting effective collaboration in the healthcare domain are numerous. Through our systematic review, we have identified the characteristics of studies that have examined collaboration and HIT. We present the collaboration space model as one approach to integrate these different characteristics. In order to both evaluate how HIT affects collaboration and identify how we can build HIT to effectively support collaboration, we encourage more studies that explicitly focus on collaborative issues in the biomedical informatics community.

Funding

This work is supported in part by National Science Foundation grants IIS #1017247 and #0844947 and by a Discovery grant from the Natural Sciences and Engineering Research Council of Canada. This material is also based upon work supported by the National Science Foundation under Grant No. DGE1255832. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Conflict of interest

We have no known conflicts of interest.

Acknowledgment

We would like to thank Bryan Steitz for his assistance in the preliminary work before the final literature collection and analysis.

Appendix A

(See Table A.1).

References

[1] C.R. Weir, K.W. Hammond, P.J. Embi, E.N. Efthimiadis, S.M. Thielke, A.N. Hedeen, An exploration of the impact of computerized patient documentation on clinical collaboration, Int. J. Med. Inform. 80 (2011) e62–e71, http://dx.doi.org/10.1016/j.ijmedinf.2011.01.003.
[2] W. Pratt, M.C. Reddy, D.W. McDonald, P. Tarczy-Hornoch, J.H. Gennari, Incorporating ideas from computer-supported cooperative work, J. Biomed. Inform. 37 (2004) 128–137, http://dx.doi.org/10.1016/j.jbi.2004.04.001.
[3] N. Elmarzouqi, E. Garcia, J.C. Lapayre, CSCW from coordination to collaboration, Comput. Support. Coop. Work Des. IV 5236 (2008) 87–98, http://dx.doi.org/10.1007/978-3-540-92719-8_9.
[4] H. Fuks, A. Raposo, M. Gerosa, The 3c collaboration model, Encycl. E-Collaboration (2008) 637–644, http://dx.doi.org/10.4018/978-1-59904-000-4.
[5] I. Steinmacher, A.P. Chaves, M.A. Gerosa, Awareness support in distributed software development: a systematic review and mapping of the literature, Comput. Support. Coop. Work 22 (2013) 113–158, http://dx.doi.org/10.1007/s10606-012-9164-4.
[6] IOM. Crossing the quality chasm: a new health system for the twenty-first century. Inst. Med., 2001.
[7] AAMC. Core competencies for interprofessional collaborative practice. Report of an expert panel. Interprofessional Educ. Collab., 2011.
[8] C.a. Gassert, The challenge of meeting patients' needs with a national nursing informatics agenda, J. Am. Med. Inform. Assoc. 5 (1998) 263–268.
[9] C. Locatis, P. Fontela, C. Sneiderman, M. Ackerman, S. Uijtdehaage, C. Candler, et al., Webcasting videoconferences over IP: a synchronous communication experiment, J. Am. Med. Inform. Assoc. 10 (2003) 150–153, http://dx.doi.org/10.1197/jamia.M1170.
[10] A. Xyrichis, K. Lowton, What fosters or prevents interprofessional teamworking in primary and community care? a literature review, Int. J. Nurs. Stud. 45 (2008) 140–153, http://dx.doi.org/10.1016/j.ijnurstu.2007.01.015.
[11] R.V. Kilgore, R.W. Langford, Reducing the failure risk of interdisciplinary healthcare teams, Crit. Care Nurs. Q. 32 (2009) 81–88, http://dx.doi.org/10.1097/CNQ.0b013e3181a27af2.
[12] S.C. Porter, Patients as Experts: A Collaborative Performance Support System, AMIA, Washington, D.C., 2001. pp. 548–552.

[13] J. Aarts, J. Ash, M. Berg, Extending the understanding of computerized physician order entry: implications for professional collaboration, workflow and quality of care, Int. J. Med. Inform. 76 (2006) S4–S13, http://dx.doi.org/10.1016/j.ijmedinf.2006.05.009.

[14] F. Malamateniou, G. Vassilacopoulos, Developing a virtual patient record using XML and web-based workflow technologies, Int. J. Med. Inform. 70 (2003) 131–139, http://dx.doi.org/10.1016/S1386-5056(03)00039-X.

[15] M. Poulymenopoulou, F. Malamateniou, G. Vassilacopoulos, Emergency healthcare process automation using workflow technology and web services, Med. Inform. Internet Med. 28 (2003) 195–207, http://dx.doi.org/10.1080/14639230310001617841.

[16] J.S. Ash, M. Berg, E. Coiera, J.S. Ash, M. Berg, E. Coiera, V. Paper, J.S. Ash, M. Berg, E. Coiera, et al., Some unintended consequences of information technology in health care: the nature of patient care information system-related errors, J. Am. Med. Inform. Assoc. 11 (2004) 104–112, http://dx.doi.org/10.1197/jamia.M1471.Medica.

[17] Journal Rankings. SJR SCImago J Ctry Rank 2015. <http://www.scimagojr.com/journalrank.php?category=2718> (accessed 31.03.15).

[18] N. Taylor, R. Clay-Williams, E. Hogden, J. Braithwaite, O. Groene, High performing hospitals: a qualitative systematic review of associated factors and practical strategies for improvement, BMC Health Serv. Res. 15 (2015) 244, http://dx.doi.org/10.1186/s12913-015-0879-z.

[19] A. Tong, K. Flemming, E. McInnes, S. Oliver, J. Craig, Enhancing transparency in reporting the synthesis of qualitative research: ENTREQ, BMC Med. Res. Methodol. 12 (2012) 181, http://dx.doi.org/10.1186/1471-2288-12-181.

[20] A. Kuper, L. Lingard, W. Levinson, Critically appraising qualitative research, BMJ 337 (2008) 687–689, http://dx.doi.org/10.1136/bmj.a1035.

[21] M. Ackerman, C. Locatis, Advanced networks and computing in healthcare, J. Am. Med. Inform. Assoc. 18 (2011) 523–528, http://dx.doi.org/10.1136/amiajnl-2010-000054.

[22] K.H. Bowles, B. Riegel, M.G. Weiner, H. Glick, M.D. Naylor, The Effect of Telehomecare on Heart Failure Self Care, AMIA, 2010. pp. 71–75.

[23] A.G. Ekeland, A. Bowes, S. Flottorp, Effectiveness of telemedicine: a systematic review of reviews, Int. J. Med. Inform. 79 (2010) 736–771, http://dx.doi.org/10.1016/j.ijmedinf.2010.08.006.

[24] G. Falkman, M. Gustafsson, M. Jontell, O. Torgersson, SOMWeb: a semantic web-based system for supporting collaboration of distributed medical communities of practice, J. Med. Internet Res. 10 (2008), http://dx.doi.org/10.2196/jmir.105.

[25] L. Gong, C.a. Kulikowski, S. Chang, An Intelligent Groupware Environment for Real-time Distributed Medical Collaboration, AMIA, 1997. p. 959.

[26] K. Hori, T. Kuroda, H. Oyama, Y. Ozaki, T. Nakamura, T. Takahashi, Improving precise positioning of surgical robotic instruments by a three-side-view presentation system on telesurgery, J. Med. Syst. 29 (2005) 661–670, http://dx.doi.org/10.1007/s10916-005-6134-0.

[27] V. Jagannathan, Y.V. Reddy, K. Srinivas, R. Karinthi, R. Shank, S. Reddy, et al., An Overview of the CERC ARTEMIS Project, AMIA, 1995. pp. 12–16.

[28] S. Jarvis-Selinger, E. Chan, R. Payne, K. Plohman, K. Ho, Clinical telehealth across the disciplines: lessons learned, Telemed. J. E-Health 14 (2008) 720–725, http://dx.doi.org/10.1089/tmj.2007.0108.

[29] S. Jarvis-Selinger, J. Bates, Y. Araki, S.a. Lear, Internet-based support for cardiovascular disease management, Int. J. Telemed. Appl. 2011 (2011), http://dx.doi.org/10.1155/2011/34258.

[30] I. Klapan, L. Šimičić, R. Rišavi, N. Bešenski, K. Pasarić, D. Gortan, et al., Tele-3-dimensional computer-assisted functional endoscopic sinus surgery: new dimension in the surgery of the nose and paranasal sinuses, Otolaryngol. – Head Neck Surg. 127 (2002) 549–557, http://dx.doi.org/10.1067/mhn.2002.129732.

[31] J.F. Kulik, X. de la Tribonnière, N. Bricon-Souf, R.J. Beuscart, Y. Mouton, Telemedicine for AIDS Patients Accommodations, vol. 2, AMIA, 1997. pp. 379–382.

[32] J.S. Lee, C.T. Tsai, C.H. Pen, H.C. Lu, A real time collaboration system for teleradiology consultation, Int. J. Med. Inform. 72 (2003) 73–79, http://dx.doi.org/10.1016/S1386-5056(03)00130-8.

[33] A. Obstfelder, K.H. Engeseth, R. Wynn, Characteristics of successfully implemented telemedical applications, Implement Sci. 2 (2007) 25, http://dx.doi.org/10.1186/1748-5908-2-25.

[34] F. Paganelli, E. Spinicci, D. Giuli, ERMHAN: a context-aware service platform to support continuous care networks for home-based assistance, Int. J. Telemed. Appl. 2008 (2008), http://dx.doi.org/10.1155/2008/86763.

[35] A. Qureshi, E. Shih, I. Fan, J. Carlisle, D. Brezinski, M. Kleinman, et al., Improving Patient Care by Unshackling Telemedicine: Adaptively Constructing Rich Wireless Communication Channels to Facilitate Continuous Remote Collaboration, AMIA, 2010. pp. 1–5.

[36] R.S. Raman, R. Reddy, V. Jagannathan, S. Reddy, K.J. Cleetus, K. Srinivas, A Strategy for the Development of Secure Telemedicine Applications, AMIA, 1997. pp. 344–348.

[37] R. Reddy, V. Jagannathan, K. Srinivas, R. Karinthi, S.M. Reddy, C. Gollapudy, et al., ARTEMIS: a collaborative framework for health care, Comput. Appl. Med. Care (1993) 559–563.

[38] S. Reddy, Y.V. Reddy, H.C. Galfalvy, V. Jagannathan, R. Raman, K. Srinivas, et al., Experiences with ARTEMIS – An Internet-based Telemedicine System, AMIA, 1997. pp. 759–763.

[39] C. Ruesch, J. Mossakowski, J. Forrest, M. Hayes, M. Jahrsdoerfer, E. Comeau, et al., Using nursing expertise and telemedicine to increase nursing collaboration and improve patient outcomes, Telemed. E-Health 18 (2012) 591–595, http://dx.doi.org/10.1089/tmj.2011.0274.

[40] M.Y. Sung, M.S. Kim, E.J. Kim, J.H. Yoo, M.W. Sung, CoMed: a real-time collaborative medicine system, Int. J. Med. Inform. 57 (2000) 117–126, http://dx.doi.org/10.1016/S1386-5056(00)00060-5.

[41] G. Welch, D.H. Sonnenwald, H. Fuchs, B. Cairns, K.M. Patel, H.M. Söderholm, et al., 3D medical collaboration technology to enhance emergency healthcare, J. Biomed. Discov. Collab. 4 (2009) 1–29.

[42] G. Zangara, F. Valentino, G. Spinelli, M. Valenza, A. Marcheggiani, F. Di Blasi, An Albanian open source telemedicine platform, Telemed. E-Health 20 (2014) 673–677, http://dx.doi.org/10.1089/tmj.2013.0239.

[43] J. Abraham, T. Kannampallil, M.C. Reddy, Peripheral Activities During EMR Use in Emergency Care: A Case Study, AMIA, 2009. pp. 1–5.

[44] S. Bringay, C. Barry, J. Charlet, Annotations for the Collaboration of the Health Professionals, AMIA, 2006. pp. 91–95.

[45] D.a. Dorr, S.S. Jones, A. Wilcox, A framework for information system usage in collaborative care, J. Biomed. Inform. 40 (2007) 282–287, http://dx.doi.org/10.1016/j.jbi.2006.10.00.

[46] M.a. Feufel, F.E. Robinson, V.L. Shalin, The impact of medical record technologies on collaboration in emergency medicine, Int. J. Med. Inform. 80 (2011) 85–95, http://dx.doi.org/10.1016/j.ijmedinf.2010.09.00.

[47] G.L. Kreps, L. Neuhauser, New directions in eHealth communication: opportunities and challenges, Patient Educ. Couns. 78 (2010) 329–336, http://dx.doi.org/10.1016/j.pec.2010.01.013.

[48] H. Laitinen, M. Kaunonen, P. Astedt-Kurki, The impact of using electronic patient records on practices of reading and writing, Health Inform. J. 20 (2014) 235–249, http://dx.doi.org/10.1177/1460458213492445.

[49] I. Maglogiannis, C. Delakouridis, L. Kazatzopoulos, Enabling collaborative medical diagnosis over the internet via peer-to-peer distribution of electronic health records, J. Med. Syst. 30 (2006) 107–116, http://dx.doi.org/10.1007/s10916-005-7984-1.

[50] L. Melby, R. Hellesø, Introducing electronic messaging in Norwegian healthcare: unintended consequences for interprofessional collaboration, Int. J. Med. Inform. 83 (2014) 343–353, http://dx.doi.org/10.1016/j.ijmedinf.2014.02.001.

[51] C. Morrison, G. Fitzpatrick, A. Blackwell, Multi-disciplinary collaboration during ward rounds: embodied aspects of electronic medical record usage, Int. J. Med. Inform. 80 (2011) e96–e111, http://dx.doi.org/10.1016/j.ijmedinf.2011.01.007.

[52] Y. Niimi, K. Ota, Display methods of electronic patient record screens: patient privacy concerns, Stud. Health Technol. Inform. 192 (2013) 1029, http://dx.doi.org/10.3233/978-1-61499-289-9-1029.

[53] M.C. Reddy, M.M. Shabot, E. Bradner, Evaluating collaborative features of critical care systems: a methodological study of information technology in surgical intensive care units, J. Biomed. Inform. 41 (2008) 479–487, http://dx.doi.org/10.1016/j.jbi.2008.01.004.

[54] D.M. Stein, J.O. Wrenn, P.D. Stetson, S. Bakken, What "to-do" with Physician Task Lists: Clinical Task Model Development and Electronic Health Record Design Implications, AMIA, 2009. pp. 624–628.

[55] Z. Tang, J. Mazabob, L. Weavind, E. Thomas, T.R. Johnson, A Time-motion Study of Registered Nurses' Workflow in Intensive Care Unit Remote Monitoring, AMIA, Washington, D.C., 2006. pp. 759–763.

[56] D.K. Vawdrey, L.G. Wilcox, S. Collins, S. Feiner, O. Mamykina, D.M. Stein, et al., Awareness of the care team in electronic health records, Appl. Clin. Inform. 2 (2011) 395–405, http://dx.doi.org/10.4338/ACI-2011-05-RA-0034.

[57] J. Viitanen, H. Hyppönen, T. Lääveri, J. Vänskä, J. Reponen, I. Winblad, National questionnaire study on clinical ICT systems proofs: physicians suffer from poor usability, Int. J. Med. Inform. 80 (2011) 708–725, http://dx.doi.org/10.1016/j.ijmedinf.2011.06.010.

[58] H. Karasti, J. Reponen, O. Tervonen, K. Kuutti, The teleradiology system and changes in work practices, Comput. Methods Programs Biomed. 57 (1998) 69–78, http://dx.doi.org/10.1016/S0169-2607(98)00047-9.

[59] J. Abraham, M.C. Reddy, Challenges to inter-departmental coordination of patient transfers: a workflow perspective, Int. J. Med. Inform. 79 (2010) 112–122, http://dx.doi.org/10.1016/j.ijmedinf.2009.11.001.

[60] G.L. Alexander, K.S. Pasupathy, L.M. Steege, E.B. Strecker, K.M. Carley, Multi-disciplinary communication networks for skin risk assessment in nursing homes with high IT sophistication, Int. J. Med. Inform. 83 (2014) 581–591, http://dx.doi.org/10.1016/j.ijmedinf.2014.05.001.

[61] S. Alsalamah, W.A. Gray, J. Hilton, H. Alsalamah, Information security requirements in patient-centred healthcare support systems, Stud. Health Technol. Inform. 192 (2013) 812–816, http://dx.doi.org/10.3233/978-1-61499-289-9-812.

[62] C. Broome, A. Adams, What gets missed when deploying new technologies in A&E?, Med Inform. Internet Med. 30 (2005) 83–87, http://dx.doi.org/10.1080/14639230500298750.

[63] R.G. Cady, S.M. Finkelstein, A Mixed Methods Approach for Measuring the Impact of Delivery-centric Interventions on Clinician Workflow, vol. 2012, AMIA, 2012. pp. 1168–1175.

[64] C.E. Kuziemsky, L. Varpio, A model of awareness to enhance our understanding of interprofessional collaborative care delivery and health information system design to support it, Int. J. Med. Inform. 80 (2011) 150–160, http://dx.doi.org/10.1016/j.ijmedinf.2011.01.009.

[65] V.L. Patel, J. Zhang, N.a. Yoskowitz, R. Green, O.R. Sayan, Translational cognition for decision support in critical care environments: a review, J.

Biomed. Inform. 41 (2008) 413–431, http://dx.doi.org/10.1016/j.jbi.2008.01.01.
[66] C.L. Plasters, F.J. Seagull, Y. Xiao, Coordination Challenges in Operating-room Management: An In-depth Field Study, AMIA, 2003. pp. 524–528.
[67] D. Swinglehurst, T. Greenhalgh, J. Russell, M. Myall, Receptionist input to quality and safety in repeat prescribing in UK general practice: ethnographic case study, BMJ 343 (2011) d6788, http://dx.doi.org/10.1136/bmj.d6788.
[68] K.M. Unertl, M. Weinger, K. Johnson, Variation in Use of Informatics Tools Among Providers in a Diabetes Clinic, AMIA, 2007. p. 756–760.
[69] A.M. Westerling, J.T. Hynninen, V.E. Haikala, M.S. Airaksinen, Opinion comparison concerning future information technology in Finnish community pharmacies, Pharm. World Sci. 32 (2010) 787–794, http://dx.doi.org/10.1007/s11096-010-9438-1.
[70] S. Berhe, S. Demurjian, R. Saripalle, T. Agresta, J. Liu, A. Cusano, et al., Secure, Obligated and Coordinated Collaboration in Health Care for the Patient-centered Medical Home, vol. 2010, AMIA, 2010. pp. 36–40.
[71] D. Pinelle, C. Gutwin, A Collaborative Document Repository for Home Care Teams, AMIA, 2005. p. 1082.
[72] M.-P. Gagnon, F. Légaré, J.-P. Fortin, L. Lamothe, M. Labrecque, J. Duplantie, An integrated strategy of knowledge application for optimal e-health implementation: a multi-method study protocol, BMC Med. Inform. Decis. Mak. 8 (2008) 17, http://dx.doi.org/10.1186/1472-6947-8-17.
[73] R.L. Simpson, Caring communications: how technology enhances interpersonal relations, Part II, Nurs. Admin. Q. 32 (2008) 159–162, http://dx.doi.org/10.1097/01.NAQ.0000305950.54063.76.
[74] V. Vimarlund, T. Timpka, V.L. Patel, Information Technology and Knowledge Exchange in Health-care Organizations, AMIA, Washington, D.C., 1999. pp. 632–636.
[75] H.W. Wu, P.K. Davis, D.S. Bell, Advancing clinical decision support using lessons from outside of healthcare: an interdisciplinary systematic review, BMC Med. Inform. Decis. Mak. 12 (2012) 90, http://dx.doi.org/10.1186/1472-6947-12-90.
[76] R.C. Wu, V. Lo, P. Rossos, C. Kuziemsky, K.J. O'leary, J.a. Cafazzo, et al., Improving hospital care and collaborative communications for the 21st century: key recommendations for general internal medicine, J. Med. Internet Res. 14 (2012) 1–12, http://dx.doi.org/10.2196/ijmr.2022.
[77] M. Bång, A. Larsson, H. Eriksson, Design requirements for ubiquitous computing environments for healthcare professionals augmenting physical workspaces, World. Congr. Med. Inform. (2004) 1416–1420.
[78] M. Bång, A. Larsson, H. Eriksson, NOSTOS: A Paper-based Ubiquitous Computing Healthcare Environment to Support Data Capture and Collaboration, AMIA, Washington, D.C., 2003. pp. 46–50.
[79] L. McKnight, P.D. Stetson, S. Bakken, C. Curran, J.J. Cimino, Perceived Information Needs and Communication Difficulties of Inpatient Physicians and Nurses, AMIA, 2001, http://dx.doi.org/10.1197/jamia.M1230. pp. 453–457.
[80] D.a. Mejía, J. Favela, A.L. Morán, Understanding and supporting lightweight communication in hospital work, IEEE Trans. Inf Technol. Biomed. 14 (2010) 140–146, http://dx.doi.org/10.1109/TITB.2009.203338.
[81] J.M. Schraagen, F. Verhoeven, Methods for studying medical device technology and practitioner cognition: the case of user-interface issues with infusion pumps, J. Biomed. Inform. 46 (2013) 181–195, http://dx.doi.org/10.1016/j.jbi.2012.10.005.
[82] J. Starmer, D. Giuse, A Real-time Ventilator Management Dashboard: Toward Hardwiring Compliance with Evidence-based Guidelines, AMIA, 2008. pp. 702–706.
[83] C. Buono, R. Huang, S. Brown, T.C. Chan, J. Killeen, L. Lenert, Role-tailored Software Systems for Coordinating Care at Disaster Sites: Enhancing Collaboration Between the Base Hospitals with the Field, AMIA, Washington, D.C., 2006. p. 867.
[84] G. Ganiatsas, K. Starida, D.I. Fotiadis, A. Likas, Childcares: an intelligent collaborative environment for out-of-hospital child healthcare, Health Inform. J. 8 (2002) 181–190, http://dx.doi.org/10.1177/146045820200800404.
[85] P. Karlsudd, E-collaboration for children with functional disabilities, Telemed. J. eHealth 14 (2008) 687–694, http://dx.doi.org/10.1089/tmj.2007.0112.
[86] M. Kaspar, N.M. Parsad, J.C. Silverstein, An optimized web-based approach for collaborative stereoscopic medical visualization, J. Am. Med. Inform. Assoc. 20 (2013) 535–543, http://dx.doi.org/10.1136/amiajnl-2012-001057.
[87] S.W. Ong, S.V. Jassal, E. Porter, A.G. Logan, J.a. Miller, Using an electronic self-management tool to support patients with chronic kidney disease (CKD): a CKD clinic self-care model, Semin. Dial. 26 (2013) 195–202, http://dx.doi.org/10.1111/sdi.1205.
[88] S. Zhu, M. Reddy, J. Yen, C. Deflitch, P. State, H. Medical, SRCAST-Diagnosis: Understanding How Different Members of a Patient-care Team Interact with Clinical Decision Support System, AMIA, 2011. pp. 1658–1667.
[89] C. Safran, The collaborative edge: patient empowerment for vulnerable populations, Int. J. Med. Inform. 69 (2003) 185–190.
[90] C. Safran, G. Pompilio-Weitzner, K.D. Emery, L. Hampers, A Medicaid eHealth Program: An Analysis of Benefits to Users and Nonusers, AMIA, 2005. pp. 659–663.
[91] A. Atwal, A. Money, M. Harvey, Occupational therapists' views on using a virtual reality interior design application within the pre-discharge home visit process, J. Med. Internet Res. 16 (2014) e283, http://dx.doi.org/10.2196/jmir.3723.
[92] R. Wu, L. Appel, D. Morra, V. Lo, S. Kitto, S. Quan, Short message service or disService: issues with text messaging in a complex medical environment, Int. J. Med. Inform. 83 (2014) 278–284, http://dx.doi.org/10.1016/j.ijmedinf.2014.01.003.
[93] M. Bång, T. Timpka, Ubiquitous computing to support co-located clinical teams: using the semiotics of physical objects in system design, Int. J. Med. Inform. 76 (2007) 58–64, http://dx.doi.org/10.1016/j.ijmedinf.2006.05.027.
[94] J.S. Ash, J. Lyman, J. Carpenter, L. Fournier, A Diffusion of Innovations Model of Physician Order Entry, AMIA, 2001. pp. 22–26.
[95] G.R. Kim, M.R. Miller, M.a. Ardolino, J.E. Smith, D.C. Lee, C.U. Lehmann, Capture and Classification of Problems During CPOE Deployment in an Academic Pediatric Center, AMIA, 2007. pp. 414–417.
[96] H.S. Wentzer, U. Böttger, N. Boye, Unintended transformations of clinical relations with a computerized physician order entry system, Int. J. Med. Inform. 76S (2007) S456–S461, http://dx.doi.org/10.1016/j.ijmedinf.2007.07.007.
[97] J.A. Nielsen, S.A. Mengiste, Analysing the diffusion and adoption of mobile IT across social worlds, Health Inform. J. 20 (2014) 87–103, http://dx.doi.org/10.1177/1460458213481688.
[98] M.C. Reddy, W. Pratt, D.W. McDonald, M.M. Shabot, Challenges to Physicians' Use of a Wireless Alert Pager, AMIA, 2003. pp. 544–548.
[99] J.C. Hsieh, A.H. Li, C.C. Yang, Mobile, cloud, and big data computing: contributions, challenges, and new directions in telecardiology, Int. J. Environ. Res. Public Health 10 (2013) 6131–6153, http://dx.doi.org/10.3390/ijerph10116131.
[100] S.a. Paul, M. Reddy, J. Abraham, C. DeFlitch, The Usefulness of Information and Communication Technologies in Crisis Response, AMIA, 2008. pp. 561–565.
[101] G. Shih, P. Lakhani, P. Nagy, Is android or iphone the platform for innovation in imaging informatics, J. Digit. Imaging 23 (2010) 2–7, http://dx.doi.org/10.1007/s10278-009-9242-4.
[102] P.G. Farup, V. Skar, Collaboration by use of the Internet yields data of high quality and detects non-uniform management of patients with Helicobacter pylori infection, Scand. J. Gastroenterol. 37 (2002) 1466–1470, http://dx.doi.org/10.1080/003655202762671378.
[103] A. Martínez-García, A. Moreno-Conde, F. Jódar-Sánchez, S. Leal, C. Parra, Sharing clinical decisions for multimorbidity case management using social network and open-source tools, J. Biomed. Inform. 46 (2013) 977–984, http://dx.doi.org/10.1016/j.jbi.2013.06.007.
[104] M. Van der Eijk, M.J. Faber, J.W.M. Aarts, J.a.M. Kremer, M. Munneke, B.R. Bloem, Using online health communities to deliver patient-centered care to people with chronic conditions, J. Med. Internet Res. 15 (2013), http://dx.doi.org/10.2196/jmir.247.
[105] A. Wright, D.W. Bates, B. Middleton, T. Hongsermeier, V. Kashyap, S.M. Thomas, et al., Creating and sharing clinical decision support content with Web 2.0: issues and examples, J. Biomed. Inform. 42 (2009) 334–346, http://dx.doi.org/10.1016/j.jbi.2008.09.003.
[106] M. Stellefson, B. Chaney, A.E. Barry, E. Chavarria, B. Tennant, K. Walsh-Childers, et al., Web 2.0 chronic disease self-management for older adults: a systematic review, J. Med. Internet Res. 15 (2013) 1–21, http://dx.doi.org/10.2196/jmir.2439.
[107] L. Macyszyn, B. Lega, L.E. Bohman, A. Latefi, M.J. Smith, N.R. Malhotra, et al., Implementation of a departmental picture archiving and communication system: a productivity and cost analysis, Neurosurgery 73 (2013) 528–533, http://dx.doi.org/10.1227/01.neu.0000431474.49042.5b.
[108] M. Bruun-Rasmussen, K. Bernstein, C. Chronaki, Collaboration-a new IT-service in the next generation of regional health care networks, Stud. Health Technol. Inform. 90 (2002) 815–820, http://dx.doi.org/10.3233/978-1-60750-934-9-815.
[109] B. Kane, S. Luz, "Do no harm": fortifying MDT collaboration in changing technological times, Int. J. Med. Inform. 82 (2013) 613–625, http://dx.doi.org/10.1016/j.ijmedinf.2013.03.003.
[110] K.C. Nanji, J. Cina, N. Patel, W. Churchill, T.K. Gandhi, E.G. Poon, Overcoming barriers to the implementation of a pharmacy bar code scanning system for medication dispensing: a case study, J. Am. Med. Inform. Assoc. 16 (2009) 645–650, http://dx.doi.org/10.1197/jamia.M3107.
[111] B. Reeder, G. Demiris, K.D. Marek, Older adults' satisfaction with a medication dispensing device in home care, Inform. Health Soc. Care 38 (2013) 211–222, http://dx.doi.org/10.3109/17538157.2012.741084.
[112] P. Tiwari, J. Warren, K. Day, Empowering Older Patients to Engage in Self Care: Designing an Interactive Robotic Device, AMIA, 2011. pp. 1402–1411.
[113] Y.F. Chang, C.C. Chen, P.Y. Chang, A robust and novel dynamic-ID-based authentication scheme for care team collaboration with smart cards, J. Med. Syst. 37 (2013), http://dx.doi.org/10.1007/s10916-012-9909-.
[114] S. Parlak, A. Sarcevic, I. Marsic, R.S. Burd, Introducing RFID technology in dynamic and time-critical medical settings: requirements and challenges, J. Biomed. Inform. 45 (2012) 958–974, http://dx.doi.org/10.1016/j.jbi.2012.04.003.
[115] J.S. Ash, P.N. Gorman, M. Lavelle, T.H. Payne, T.A. Massaro, G.L. Frantz, et al., A cross-site qualitative study of physician order entry, J. Am. Med. Inform. Assoc. 10 (2003) 188–200, http://dx.doi.org/10.1197/jamia.M770.Computerized.
[116] Z. Tang, L. Weavind, J. Mazabob, E.J. Thomas, M.Y.L. Chu-Weininger, T.R. Johnson, Workflow in intensive care unit remote monitoring: a time-and-motion study, Crit. Care Med. 35 (2007) 2057–2063, http://dx.doi.org/10.1097/01.CCM.0000281516.84767.96.

[117] Sa Paul, M.C. Reddy, C.J. DeFlitch, Information and Communication Tools as Aids to Collaborative Sensemaking. CHI 2008, ACM, Florence, Italy, 2008, http://dx.doi.org/10.1145/1358628.1358815. pp. 3105–3110.
[118] K.M. Unertl, L.L. Novak, K.B. Johnson, N.M. Lorenzi, Traversing the many paths of workflow research: developing a conceptual framework of workflow terminology through a systematic literature review, J. Am. Med. Inform. Assoc. 17 (2010) 265–273, http://dx.doi.org/10.1136/jamia.2010.004333.
[119] Z. Niazkhani, H. Pirnejad, M. Berg, J. Aarts, The impact of computerized provider order entry systems on inpatient clinical workflow: a literature review, J. Am. Med. Inform. Assoc. 16 (2009) 539–549, http://dx.doi.org/10.1197/jamia.M2419.
[120] C.E. Kuziemsky, L. Varpio, Describing the Clinical Communication Space Through a Model of Common Ground: 'you don't know what you don't know', AMIA, 2010. pp. 407–411.
[121] P. Mattessich, M. Murray -Close, B. Monsey, Collaboration: What Makes It Work, second ed., Wilder Publishing Centre, Minnesota, USA, 2001.
[122] C. Castelfranchi, Modeling social action for AI agents, IJCAI Int. Jt. Conf. Artif. Intell. 2 (1997) 1567–1576, http://dx.doi.org/10.1016/S0004-3702(98)00056-3.
[123] S.a. Collins, K. Bavuso, G. Zuccotti, R.a. Rocha, Lessons learned for collaborative clinical content development, Appl. Clin. Inform. 4 (2013) 304–316, http://dx.doi.org/10.4338/ACI-2013-02-CR-001.
[124] C.E. Kuziemsky, T.L. O'Sullivan, A model for common ground development to support collaborative health communities, Soc. Sci. Med. 128 (2015) 231–238, http://dx.doi.org/10.1016/j.socscimed.2015.01.032.
[125] C. Safran, P.C. Jones, D. Rind, B. Bush, K.N. Cytryn, V.L. Patel, Electronic communication and collaboration in a health care practice, Artif. Intell. Med. 12 (1998) 137–151, http://dx.doi.org/10.1016/S0933-3657(97)00047-X.
[126] E. Coiera, When conversation is better than computation, J. Am. Med. Inform. Assoc. 7 (2000) 277–286.
[127] S.a. Collins, S. Bakken, D.K. Vawdrey, E. Coiera, L. Currie, Model development for EHR interdisciplinary information exchange of ICU common goals, Int. J. Med. Inform. 80 (2011) e141–e149, http://dx.doi.org/10.1016/j.ijmedinf.2010.09.00.
[128] M. Gagnon, E. Nsangou, J. Payne-Gagnon, S. Grenier, C. Sicotte, Barriers and facilitators to implementing electronic prescription: a systematic review of user groups' perceptions, J. Am. Med. Inform. Assoc. (2013), http://dx.doi.org/10.1136/amiajnl.
[129] D. Giardina, S. Menon, D. Parrish, D. Sittig, H. Singh, Patient access to medical records and healthcare outcomes: a systematic review, J. Am. Med. Inform. Assoc. (2013), http://dx.doi.org/10.1136/amiajnl.
[130] F. Lau, C. Kuziemsky, M. Price, J. Gardner, A review on systematic reviews of health information system studies, J. Am. Med. Inform. Assoc. 17 (2010) 637–645, http://dx.doi.org/10.1136/jamia.2010.004838.
[131] T. Greenhalgh, G. Robert, F. MacFarlane, P. Bate, O. Kyriakidou, Diffusion of innovations in service organizations: systematic review and recommendations, Milbank Q. 82 (2004) 581–628, http://dx.doi.org/10.1111/j.0887-378X.2005.340_1.x.
[132] K.M. Unertl, M.B. Weinger, K.B. Johnson, N.M. Lorenzi, Describing and modeling workflow and information flow in chronic disease care, J. Am. Med. Inform. Assoc. 16 (2009) 826–836, http://dx.doi.org/10.1197/jamia.M3000.
[133] Z. Niazkhani, H. Pirnejad, H. van der Sijs, J. Aarts, Evaluating the medication process in the context of CPOE use: the significance of working around the system, Int. J. Med. Inform. 80 (2011) 490–506, http://dx.doi.org/10.1016/j.ijmedinf.2011.03.009.
[134] Z. Niazkhani, H. Pirnejad, H. van der Sijs, A. de Bont, J. Aarts, Computerized provider order entry system – does it support the inter-professional medication process? lessons from a Dutch academic hospital, Methods Inf. Med. 49 (2010) 20–27, http://dx.doi.org/10.3414/ME0631.
[135] H. Pirnejad, Z. Niazkhani, H. van der Sijs, M. Berg, R. Bal, Evaluation of the impact of a CPOE system on nurse-physician communication: a mixed method study, Methods Inf. Med. 48 (2009) 350–360, http://dx.doi.org/10.3414/ME0572.